Research and Development Technical Report

ECOM -4460

EVALUATION OF THE TUNABLE SOLID STATE POWER AMPLIFIER FOR RECEIVER-TRANSMITTERS RT-246/VRC AND RT-524/VRC

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January 1977

ECOM

US ARMY ELECTRONICS COMMAND FORT MONMOUTH, NEW JERSEY 07703

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1. REPORT NUMBER: ECOM-4160	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Evaluation of the Tunable Solid State Power Amplifier for Receiver-Transmitters RT-246/VRC and RT-524/VRC.	5. TYPE OF REPORT & PERIOD COVERED: FINAL rept. June – August 1976.
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): WALTER D. PATTERSON	8. CONTRACT OR GRANT NUMBER(s): 46p.
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Electronics Command, ATTN: DRSEL-NL-RN-1, Fort Monmouth, NJ 07703	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 697348.PI3.61.34.01
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Electronics Command, ATTN: DRSEL-NL-RN-1, Fort Monmouth, NJ	12. REPORT DATE: January 1977
	13. NUMBER OF PAGES: 42
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

VHF-FM Radio	RT-246/VRC
Vehicular Radio	Transmitter Tube Replacement
AN/VRC-12	Transistorized VHF Power Amplifier
RT-524/VRC	Transmitter Noise Floor

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents results of electrical tests on the solid state power amplifier for Receiver-Transmitters RT-246/VRC and RT-524/VRC developed by the RF Communications Division of the Harris Corporation, Rochester, NY, under contract number DAAB07-75-C-0146. The equipment was tested with regard to power output at room temperature, temperature extremes, and at input voltages of 22 to 30 Vdc; spurious emissions and intermodulation; dc input requirements; amplifier protection; and duty cycle capability.

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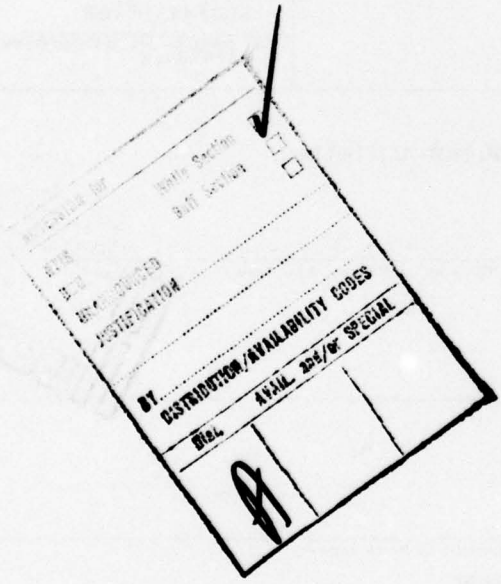
20. Abstract.

All test results show satisfactory performance of the test items. However, power output at +150°F ambient temperature and harmonic attenuation in the high band are marginal.



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1. INTRODUCTION:

Receiver-Transmitters RT-246/VRC and RT-524/VRC are frequency modulated (FM) transceivers used by the US Army in large quantities. These radios provide 920 communication channels in the frequency range of 30 to 75.95 MHz. The RT-246 has a pushbutton tuning feature for the automatic selection of ten preset channels, whereas the RT-524 is manually tuned. Both equipments provide a nominal power output of 35 watts in the high power mode, and four watts in the low power mode.

The transceivers were designed in the mid to late 1950's and were first produced in the early 1960's. They are almost completely transistorized except for the receiver front end and the transmitter power amplifier stages. In these areas, vacuum tubes are employed, because solid state technology was not sufficiently advanced at the time of development. While the receiver front end has proven to be relatively trouble free in the field environment, the current transmitter power amplifier design and its associated power supply have been the source of numerous equipment malfunctions. Low reliability at high ambient temperatures and interference to users above 100 MHz are being experienced with the current design.

The proposed modification, which is the basis for subject report, provides a transistorized tuned power amplifier and driver; a siliconized power supply; and a low pass filter when operating in the 53 - 75.95 MHz band.

2. BACKGROUND:

As a result of some previous work on high efficiency, broadband power amplifiers,[1,2] Contract No. DAAB07-72-C-0153 was awarded in September 1971 to RF Communications, Rochester, NY. The contract called for the development of a solid state power amplifier and driver in accordance with ECOM Development Specification EL-CP0108-0001A, dated 1 December 1970. The contract also called for replacement of germanium transistors in the power supply module A9400 with silicon transisotrs. In August 1972, the contractor delivered to ECOM five RT-524's with an all solid state broadband transmitter.[3-6] Preliminary testing at ECOM showed that the sets radiated excessive broadband noise due to the lack of tuning at the output of the power amplifier stage. This broadband noise along with degraded transmitter intermodulation performance greatly hindered collocation of the RT-524's and the use of these transceivers in a retransmit configuration.[7]

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1. R&D Tech Report, ECOM-2836, D.R. Lohrmann, May 1967.
2. R&D Tech Report, ECOM-3209, Dr. Lohrmann, G.R. Oliva, Dec 1969.
3. R&D Tech Report, ECOM-0153-1, A. Kurvits, RF Comm, Inc, Jan 1973.
4. R&D Tech Report, ECOM-0153-2, A.Kurvits, F. Hauer, RF Comm,Inc, Mar 1973.
5. R&D Tech Report, ECOM-0153-3, W. Herzog, F. Hauer, RF Comm,Inc, May 1973.
6. R&D Tech Report, ECOM-0153-4, W. Herzog, RF Comm, Inc, Sep 1973.
7. Test Report, Proposed Solid State Power Amplifier Modification to Radio Set RT-524/VRC - R135 Ser 4700-8, Robert Jordan, Naval Electronics Laboratory, San Diego, CA, June 1973.

Furthermore, the power output did not meet the specification and the modification was applicable only to the RT-524 and not to the RT-246. Because of these deficiencies, development of the broadband model was discontinued.

Based upon promising results obtained with a tunable solid state power amplifier designed and fabricated at ECOM[8], the specification was revised to require the broadband noise to be at least 140 dB below the carrier at frequencies which are 10 MHz or more removed from the carrier. This is equivalent to the noise performance of the current tube type amplifier.

In May 1975, the RF Communications Division of Harris Corporation, Rochester, NY, was awarded Contract No. DAAB07-75-C-0146 for the development of a tunable power amplifier which was to be incorporated into two RT-524's and one RT-246. The design of the amplifier was completed in March 1976 [9,10] and the three modified transceivers were delivered to ECOM in May 1976.

3. TEST DESCRIPTION AND RESULTS:

The electrical performance of the transceivers was tested to determine compliance with ECOM Development Specification EL-CP-0108-0001A, dated 1 December 1970 with amendments dated 23 July 1974 and 11 December 1974. In most instances, this specification is more restrictive than the current production specification, MIL-R-55100D(EL). For easy reference, the specification paragraphs which apply to a particular parameter under test are quoted. Where a requirement is not defined in MIL-R-55100D(EL), or where its definition differs from that in EL-CP0108-0001A, the typical performance of current equipment is indicated for comparison purposes.

Since the modification affects only a part of the equipment, the testing was limited to areas which are impacted by the modifications. The test results obtained by the contractor are tabulated alongside the ECOM results and are generally in good agreement. For a list of test equipment, see appendix A.

a. High power output.

Requirements: EL-CP0108-0001A, paragraph 3.4.1

"The RF power delivered to a 50 ohm resistive load shall be 35 watts minimum with 25.5 Vdc input. At 22.0 Vdc input, the high power shall be 25 watts minimum. At 30 Vdc input, the high power output shall be 55 watts maximum. This power output shall be maintained over the tuning range of 30 - 75.95 MHz."

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8. R&D Tech Report, ECOM-4419, Dieter R. Lohrmann, Walter D. Patterson, June 1976.
9. R&D Tech Report, ECOM-75-0146-1, Bruce Williams, Harris RF Comm,Inc, December 1975.
10. R&D Tech Report, ECOM-75-0146-2, Bruce Williams, Harris RF Comm, Inc, March 1976.

Paragraph 3.3.2.a, Temperature, operating:

"Ambient temperature in the range of +150°F to -40°F. (The 150°F temperature includes effect of sunload.) Exposure at the high temperature extreme not to exceed 4 hours, and at the low temperature extreme not to exceed 72 hours, at any one time."

MIL-R-55100D(EL), paragraph 3.10.1

"The rf power delivered to a 50 ohm resistive load shall be 35 watts minimum with 25.5 and 30.0 Vdc input. At 22.0 Vdc input, the high power output shall be 25 watts minimum. At 25.5 Vdc input, the power output shall be 50 watts maximum."

NOTE: In existing tube models, the power output rises from 50W to approximately 75W when the input voltage is raised from 25.5 Vdc to 30.0 Vdc. Because of the difficulties in maintaining production tolerances with changing tube parameters, the current manufacturer was granted a waiver extending the high power maximum limit to 65W at 25.5 Vdc.

The operating temperature requirement is -40°F to +150°F.

Test setup: see Figure 1.

Test results: (for test data see tables 1 thru 3)

The majority of the readings are within specification requirements and there is good agreement between government and contractor data. Set No. 2, however, exhibited significantly lower power output at 22 Vdc when tested at ECOM, than in the contractor's test. A similar situation exists in Set No. 3 at the high temperature extreme. It is also noted that the maximum specified power output is exceeded over a portion of the band in all three sets.

The tests show that the design with respect to high power output capability and regulation is marginal. Additional gain reserve and corrections to the VSWR bridge are needed to smooth its power response vs. frequency to achieve satisfactory performance.

b. Low power output.

Requirements: EL-CP0108-0001A, para 3.5.2:

"The rf power delivered to a 50 ohm resistive load shall be 1.5 - 5 watts with 25.5 Vdc input voltage. Low power output with 22.0 Vdc input shall be ½ watt minimum. Low power output with 30.0 Vdc input shall be 6 watts maximum."

MIL-R-55100D(EL), para 3.10.2.

"The rf power delivered to a 50 ohm resistive load shall be ½ to 8 watts with 25.5 Vdc input voltage. The low power output with 22.0 Vdc input shall be ½ watt minimum. The low power output with 30.0 Vdc input shall be 10 watts maximum."

NOTE: Because of difficulties in maintaining production tolerances with changing tube parameters, the current manufacturer has requested a waiver, extending the low power maximum limit to 15 watts.

Test setup: see Figure 1.

Test results: (for test data see tables 4 thru 6)

At the nominal input voltage of 25.5 Vdc, the power output remained within a range of 2 to 5 watts across the frequency band and over the complete temperature range. Excellent regulation of the output power was maintained with input voltage variations from 22 to 30 Vdc. The design with respect to low power output is satisfactory.

c. Spurious emissions.

Requirements:

EL-CP0108-001A, para 3.5.3:

"When measured in accordance with 4.4.4, the number of spurious outputs which exceed 10 dB of quieting shall be no greater than 10."

"4.4.4 Spurious emission. (See 3.5.3) The transmitter shall be operated under standard test conditions except that no modulation shall be applied. The output of the transmitter shall be connected to an approved receiver through a 50 ohm variable pad to provide 70 millivolts across the receiver antenna terminals. With the transmitter on any one of the frequencies listed below, the receiver shall be tuned throughout its tuning range and points of quieting which exceed 10 dB shall be recorded to determine compliance with 3.5.3. The test shall be conducted at transmitter frequencies of 34.50, 46.00, 57.50 and 69.00 Hz. To distinguish between receiver spurious responses and transmitter spurious emissions, quieting points shall be checked with a signal generator tuned to frequency of quieting and substituted in place of the transmitter."

MIL-R-55100D(EL), paragraphs 3.10.17 and 4.10.17 specify identical limits and procedures.

Test setup: See figure 2.

Test results: (for test data see table 7)

Five to eight points of quieting were observed. The design with respect to spurious emissions is satisfactory. No contractor data was taken in this area.

d. Transmitter noise level.

Requirements:

EL-CP0108-0001A, paragraph 3.5.4:

"The level, at any RF frequency, measured in a 30 kHz bandwidth, at + 10 MHz and/or more removed from the carrier shall be at least 145 dB below the carrier level as a design objective and 140 dB below the carrier level as a minimum requirement."

MIL-R-55100D(EL): No requirement is specified, but equipment typically meets the above requirement as shown in Figure 6a.

Test setup: See Figure 3. The noise floor of the measuring system is -102 dBm, allowing measurements to be made to a level 148 dB below the carrier level.

Test results: (See Figures 4 and 5)

The noise floor was at least 143 dB below the carrier level when operating in the low band (30 - 52.95 MHz) and at least 141 dB below the carrier level when operating in the high band (53 - 75.95 MHz). This performance is comparable to that of the current tube type amplifier (Figure 6a) and represents a better than 20 dB improvement over the performance of the broadband solid state power amplifier developed under contract number DAAB07-72-C-0153 (Figure 6b).

The design with respect to transmitter noise level is satisfactory.

e. Harmonic emission.

Requirement:

EL-CP0108-0001A, paragraph 3.5.5:

"The level of the 2nd and 3rd harmonics of the transmitter output frequency shall be at least 60 dB below the carrier level when measured in the high power position. Under the same conditions all higher order harmonics shall be at least 80 dB below the carrier."

MIL-R-55100D(EL): No requirement is specified. Current equipment typically meets or exceeds the above requirement in the low band (see Figure 7a); in the high band, however, (53 - 75.95 MHz), harmonics are attenuated only 40 - 50 dB below the carrier level (see Figure 7b), since no low pass filter is provided in this band.

Test setup: See Figure 3.

Test results: (See Figures 8 and 9)

In the low band (Figure 8), harmonics are attenuated at least 100 dB which is comparable to the performance of the tube model. While the 3rd harmonic is predominant in the solid state model, the 2nd harmonic predominates in the tube model. In the high band mode (Figure 9), the 5th harmonic is predominant and barely meets the specification requirement of 80 dB. However, this is strictly a function of the new low pass filter installed in the high band output. The filter attenuation can be

improved by 5 - 10 dB so that the 80 dB requirement will be easily meet in future models. This represents a 40 dB improvement over current equipment performance and will significantly reduce the interference to users in the upper end of the VHF spectrum and in parts of the UHF spectrum. This performance is generally in agreement with that measured by the contractor (see table 8). Except the contractor made no measurements out to the 5th harmonic in the high band.

f. Transmitter intermodulation.

Requirements:

EL-CP0108-0001A, paragraph 3.5.6:

"The third order intermodulation product, when measured in accordance with 4.4.7 shall be 20 dB below the interfering carrier level as a design objective and 15 dB below the interfering carrier level as a minimum requirement." (paragraph 4.4.7 specifies the test setup and test frequencies)

MIL-R-55100D(EL): No requirement is specified; typical equipment performance exceeds the solid state design objective by 5 to 10 dB.

Test setup: See Figure 10.

Test results: (for test data see table 9 and Figure 11).

The third order product was attenuated 23 to 27 dB below the interfering carrier level, exceeding the design objective of 20 dB. The results obtained with two measuring techniques are in good agreement.

g. RF power amplifier protection.

Requirements:

EL-CP0108-0001A, paragraph 3.5.8:

"The RF power amplifier shall be designed so that changing frequency or bands at full power output will not permanently degrade performance. There shall also be protection provided so that any standing wave ratio from short circuit to infinity will not permanently degrade the performance of the amplifier."

MIL-R-55100D(EL): No requirement is specified; protective circuitry is not provided within current equipment.

Test results:

All three sets were tested while continuously transmitting in the high power mode. Bands and frequencies were changed repeatedly, the antenna was removed and a short circuit was placed across the antenna port for 90 seconds. No damage to the equipment occurred.

h. Duty cycle.

Requirements:

EL-CP0108-0001A, paragraph 3.5.9:

"The RF power amplifier, when installed in Receiver-Transmitter RT-524()/VRC, shall be capable of continuous operation over the temperature range and input voltage requirements of this specification. All components shall be operated within their specified ratings."

MIL-R-55100D(EL): No requirement is specified. Past experience has shown that the current units cannot reliably be used in a continuous transmit mode. To achieve a continuous transmit capability in Radio Set AN/GRC-163, for example, the dc input voltage had to be set at 23 Vdc to prevent overheating.

Test results:

The transmitters were keyed for one hour at room temperature in the high power mode. No damage or excessive heating was noted.

At 150°F, the transmitter, key-down condition could not be maintained for more than 5 minutes. Excessive heat would build up in the small temperature chamber due to the chamber's inability to maintain proper heat regulation. However, no damage was observed.

i. Maximum current requirement.

Requirements:

EL-CP0108-0001A, paragraph 3.5.12:

"The total current drain of the RT-524 utilizing the transistorized rf power amplifier shall not exceed 7 amperes with a voltage supply of 25 Vdc as a design objective and shall not exceed 7.5 amperes with a voltage supply of 25 Vdc as a maximum requirement. This requirement does not include the fan."

MIL-R-55100D(EL): No requirement is specified. Typical current drain of present units is 10 to 13 amperes.

Test results: (for test data see table 10)

The input current in the high power mode, with the fan disabled, ranged from 5.5 to 8.4 amperes, the mean current drain being 6.3 amperes. Even though the specification requirement was not met at all frequency settings, a 40% improvement over the tube type model has been realized. This reduction in heat dissipation should have an overall beneficial effect on transceiver reliability.

It is not expected that the maximum current drain can realistically be held to less than 8.5 amperes. This fact will have to be recognized in any future specification requirement.

4. CONCLUSIONS:

The tunable transistor power amplifier developed under contract number DAAB07-75-C-0146 is suitable for scheduled product improvement tests by TECOM. Problem areas present in the broadband amplifier have been resolved satisfactorily. Areas of marginal performance, e.g. power output at 150°F and attenuation of harmonics in the high band, can be corrected in the production phase of the program. The maximum current requirement will have to be relaxed to allow an input current of 8.5 amperes.

TABLE 1

HIGH POWER OUTPUT, RT-524, SET #1

ECOM DATA, (CONTRACTOR DATA) WATTS

FREQUENCY (MHz)	ROOM TEMPERATURE						-40°F		+150°F	
	@ 22 Vdc		@ 30 Vdc		@ 25.5 Vdc		@ 25.5 Vdc		@ 25 Vdc	
30.00	41	(41)	45	(49)	38.5	(44)	55	(46)	48	(43)
32.00	42	(42)	46	(49)	42	(44.5)	55	(46)	48	(59)
34.00	42	(42)	46	(49)	41	(44)	56	(46)	46	(59)
36.00	43	(43)	48	(50)	44	(46)	60	(58)	46	(45)
36.70	-	-	57	-	55	-	-	-	-	-
36.85	-	-	63	-	59	-	-	-	-	-
37.00	-	-	60.5	-	58	-	-	-	-	-
37.20	-	-	60	-	55	-	-	-	-	-
37.75	-	-	55	-	50	-	-	-	-	-
38.00	40	(38)	52	(55)	48	(50)	51	(47)	46	(50)
40.00	40	(36.5)	48	(49)	44	(46)	55	(46)	48	(50)
42.00	42	(40)	47	(49)	43	(45)	54	(46)	49	(54)
44.00	41	(38)	46	(48)	42	(44)	47	(46)	44	(46)
46.00	35	(32.5)	47	(47.5)	43	(45)	43	(39)	39	(42)
48.00	31	(30)	45	(47)	38	(42)	39	(43)	38	(38)
50.00	32	(32)	43	(44.5)	38	(40)	42	(42)	37	(38)
52.00	34	(37)	43	(44)	38	(39.5)	51	(42)	41	(44)
52.95	33	(35)	41	(42)	37.5	(39)	48	(42)	32	(42)
53.00	30	(31)	50	(53)	40	(43)	47	(41)	37	(39)
54.00	-	(31)	-	(52)	-	(41)	-	(40)	-	(40)
55.00	30	-	50	-	40	-	47	-	37	-

TABLE 1, HIGH POWER OUTPUT, RT-524, SET #1 (Continued)

ECOM DATA, (CONTRACTOR DATA) WATTS

FREQUENCY	ROOM TEMPERATURE						-40°F		+150°F	
(MHz)	@ 22 Vdc		@ 30 Vdc		@ 25.5 Vdc		@ 25.5 Vdc		@ 25 Vdc	
56.00	-	(30)	-	(54)	-	(42.5	-	(42)	-	(40)
57.00	30	-	49	-	40	-	47	-	38	-
58.00	-	(29)	-	(53)	-	(42)	-	(45)	-	(40)
59.00	28	-	51	-	39	-	48	-	39	-
60.00	-	(29)	-	(54)	-	(42.5)	-	(46)	-	(40)
61.00	27	-	51	-	37	-	49	-	39	-
62.00	-	(33)	-	(54)	-	(40.5)	-	(48)	-	(41)
63.00	28	-	48	-	39	-	52	-	39	-
64.00	-	(33)	-	(54)	-	(44)	-	(50)	-	(42)
65.00	29	-	50	-	41	-	51	-	37	-
66.00	-	(31)	-	(54)	-	(44)	-	(49)	-	(45)
67.00	30	-	52	-	43	-	48	-	36	-
68.00	-	(32)	-	(53)	-	(46.5)	-	(48)	-	(46)
69.00	30	-	53	-	43	-	48	-	36	-
70.00	-	(32)	-	(54)	-	(47)	-	(49)	-	(45)
71.00	31	-	53	-	43	-	48	-	36	-
72.00	-	(33)	-	(54.5)	-	(47.5)	-	(48)	-	(42)
73.00	31	-	53	-	45	-	48	-	36	-
74.00	-	(33)	-	(53.5)	-	(46)	-	(42)	-	(39)
75.00	29	-	51	-	44	-	42	-	34	-
75.95	28	(27)	50	(53)	43	(42)	36	(36)	27	(35)

TABLE 2

HIGH POWER OUTPUT, RT-246, SET #2

ECOM DATA, (CONTRACTOR DATA)WATTS

FREQUENCY (MHz)	ROOM TEMPERATURE						-40°F		+150°F	
	@ 22 Vdc		@ 30 Vdc		@ 25.5 Vdc		@ 25.5 Vdc		@ 25 Vdc	
30.00	42	(40)	42	(50)	40	(44)	38	(54)	39	(36)
32.00	37	(42)	53	(50)	40	(47)	48	(50)	48	(45)
34.00	35	(43)	59	(52)	43.5	(48)	46	(47)	48	(46)
34.90	-	-	-	-	55	-	-	-	-	-
35.15	-	-	-	-	58.5	-	-	-	-	-
35.45	-	-	-	-	55	-	-	-	-	-
36.00	34	(45)	-	(53)	46	(50)	43	(43)	33	(44)
38.00	34	(41)	48	(50)	42	(45)	44	(39)	45	(45)
40.00	33	(38)	48	(49)	40	(43)	40	(40)	47	(42)
42.00	31	(41)	49	(50)	41	(43)	38	(31)	32	(37)
44.00	36	(39.5)	49	(48)	40.5	(44)	39	(32)	43	(40)
46.00	33	(38)	44	(47.5)	41	(44)	40	(29)	38	(35)
48.00	28	(34)	40	(43.5)	38	(42.5)	40	(35)	37	(40)
50.00	27	(31)	40	(43)	37.5	(39)	39	(40)	40	(43)
42.00	32	(34)	44	(42)	36	(38)	40	(45)	37	(42)
52.95	30	(33)	44	(41)	35.5	(38)	40	(35)	39	(35)
53.00	29	(37)	46	(45.5)	46	(42)	41	(40)	37	(44)
54.00	-	(36)	-	(46)	-	(42)	-	(39)	-	(45)
55.00	26	-	46	-	49	-	41	-	30	-
56.00	-	(35)	-	(45)	-	(41)	-	(39)	-	(45)

TABLE 2, HIGH POWER OUTPUT, RT-246, SET #2 (Continued)

ECOM DATA, (CONTRACTOR DATA) WATTS

FREQUENCY (MHz)	ROOM TEMPERATURE @ 22 Vdc		@ 30 Vdc		@ 25.5 Vdc		-40°F @25.5 Vdc		+150°F @25 Vdc	
57.00	24	-	45	-	42	-	42	-	40	-
58.00	-	(34)	-	(45)	-	(41)	-	(40)	-	(44)
59.00	20	-	46	-	40	-	43	-	40	-
60.00	-	(33)	-	(46)	-	(41)	-	(40)	-	(44)
61.00	20	-	46	-	37.5	-	44	-	42	-
62.00	-	(33)	-	(46.5)	-	(41.5)	-	(41)	-	(45)
63.00	20	-	47	-	37	-	45	-	45	-
64.00	-	(32)	-	(47)	-	(42)	-	(42)	-	(47)
65.00	20	-	47	-	36	-	45	-	44	-
66.00	-	(30)	-	(47)	-	(42)	-	(42	-	(45)
67.00	21	-	47	-	36	-	47	-	40	-
68.00	-	(30)	-	(45)	-	(41)	-	(42)	-	(46)
69.00	22	-	44	-	37.5	-	45	-	39	-
70.00	-	(33)	-	(44.5)	-	(39.5)	-	(38)	-	(46)
71.00	25	-	44	-	41	-	47	-	39	-
72.00	-	(36)	-	(44)	-	(40)	-	(39)	-	(44)
73.00	23	-	44	-	40	-	46	-	38	-
74.00	-	(32)	-	(43)	-	-	-	(38)	-	(41)
75.00	20	-	41	-	37	(40)	40	-	39	-
75.95	17	(26.5)	35	(43)	35	(40)	39	(38)	34	(36)

TABLE 3

HIGH POWER OUTPUT, RT-524, SET #3

ECOM DATA, (CONTRACTOR DATA) WATTS

FREQUENCY (MHz)	ROOM TEMPERATURE						-40°F		+150°F	
	@ 22 Vdc		@ 30 Vdc		@25.5 Vdc		@ 25.5 Vdc		@ 25 Vdc	
30.00	40	(40)	48	(47)	43	(46)	55	(40)	39	(45)
32.00	42	(42)	50	(48)	43	(44.5)	55	(39)	48	(52)
34.00	44	(41.5)	56	(48)	43.5	(45)	56	(39)	48	(51)
36.00	42	(45)	53	(60.5)	38	(56)	60	(57)	33	(52)
38.00	42	(41)	51	(52)	41	(49)	51	(44)	45	(51)
40.00	42	(40.5)	49	(50)	48	(47)	55	(41)	47	(50)
42.00	41	(41)	46	(48)	47	(46)	54	(40)	32	(50)
44.00	40	(41)	41	(48)	44.5	(44)	47	(41)	42	(43)
46.00	34	(36)	44	(47)	39.5	(43)	43	(39)	38	(38)
48.00	35	(34)	41	(45)	39.5	(42)	39	(36.5)	37	(37)
50.00	35	(34)	41	(40.5)	40.1	(38)	42	(34.5)	40	(42)
52.00	36	(35)	41	(41)	39.5	(38)	51	(35.5)	37	(43)
52.95	28	(31)	37	(44)	36	(40)	48	(37)	39	(39)
53.00	34	(34)	47	(42)	42	(43)	46	(40)	37	(43)
54.00	-	(33)	-	(47)	-	(44)	-	(40)	-	(40)
55.00	34	-	50	-	44	-	46	-	30	-
56.00	-	(32)	-	(48)	-	(42)	-	(39)	-	(43)
57.00	30	-	48	-	45	-	46	-	32	-
58.00	-	(30)	-	(47.3)	-	(40.5)	-	(39)	-	(42)
59.00	28	-	47	-	42	-	47	-	28	-

TABLE 3, HIGH POWER OUTPUT, RT-524, SET #3 (Continued)

ECOM DATA, (CONTRACTOR DATA) WATTS

FREQUENCY (MHz)	ROOM TEMPERATURE						-40°F		+150°F	
	@ 22 Vdc		@ 30 Vdc		@ 25.5 Vdc		@ 25.5 Vdc		@ 25 Vdc	
60.00	-	(30)	-	(44)	-	(40)	-	(39)	-	(41)
61.00	30	-	43	-	42	-	45	-	30	-
62.00	-	(30)	-	(44)	-	(41.5)	-	(39)	-	(41)
63.00	30	-	43	-	44	-	47	-	28	-
64.00	-	(30)	-	(43)	-	(41)	-	(38)	-	(39)
65.00	29	-	44	-	41	-	48	-	28	-
66.00	-	(31)	-	(44)	-	(41)	-	(37.5)	-	(39)
67.00	30	-	44	-	42.5	-	52	-	32	-
68.00	-	(33)	-	(44)	-	(41.5)	-	(37.5)	-	(41)
69.00	32	-	45	-	42	-	49	-	35	-
70.00	-	(35)	-	(45)	-	(41)	-	(38)	-	(43)
71.00	34	-	46	-	42	-	52	-	36	-
72.00	-	(33.5)	-	(46)	-	(43)	-	(38)	-	(42)
73.00	34	-	47	-	43	-	52	-	36	-
74.00	-	(33)	-	(46)	-	(43)	-	(39)	-	(41)
75.00	31	-	46	-	42	-	49	-	33	-
75.95	28	(29)	43	(46.5)	39	(41)	49	(39)	32	(37.5)

TABLE 4

LOW POWER OUTPUT, RT-524, SET #1

ECOM DATA, (CONTRACTOR DATA) WATTS

FREQUENCY (MHz)	ROOM TEMPERATURE			-40°F	+150°F
	@ 22 Vdc	@ 30 Vdc	@ 25.5 Vdc	@ 25.5 Vdc	@ 25 Vdc
30.00	3.4 -	3.3 -	4 (3.2)	3.8 -	3.6 -
32.00	3.4 -	3.2 -	4 (3.2)	3.8 -	3.5 -
34.00	4.2 -	3.4 -	3.9 (3.1)	4.3 -	4.6 -
36.00	3.7 -	3.6 -	4.1 (3.2)	4.2 -	3.8 -
38.00	3.4 -	3.3 -	4.4 (3.4)	4.0 -	3.6 -
40.00	3.1 -	3.0 -	3.7 (2.9)	3.6 -	3.2 -
42.00	3.1 -	3.0 -	3.6 (2.9)	3.6 -	3.2 -
44.00	3.0 -	2.9 -	3.6 (2.8)	3.5 -	3.1 -
46.00	2.9 -	2.8 -	3.4 (2.7)	3.2 -	3.0 -
48.00	3.3 -	3.1 -	3.7 (2.8)	3.8 -	3.3 -
50.00	3.2 -	2.9 -	3.6 (2.7)	3.6 -	3.1 -
52.00	2.8 -	2.6 -	3.3 (2.5)	3.2 -	2.8 -
52.95	2.6 -	2.6 -	3.3 (2.4)	3.2 -	2.9 -
53.00	3.4 -	3.3 -	4 (3.1)	3.8 -	3.6 -
54.00	3.4 -	3.3 -	- (3.1)	3.8 -	3.6 -
55.00	3.4 -	3.3 -	4.1 -	3.9 -	3.6 -
56.00	3.2 -	3.4 -	- (3)	3.9 -	3.6 -
57.00	3.2 -	3.1 -	4.1 -	3.8 -	3.5 -
58.00	3.4 -	3.3 -	- (3.1)	3.8 -	3.5 -
59.00	3.4 -	3.3 -	4.1 -	3.8 -	3.6 -

TABLE 4, LOW POWER OUTPUT, RT-524, SET #1 (CONTINUED)

ECOM DATA, (CONTRACTOR DATA) WATTS

FREQUENCY (MHz)	ROOM TEMPERATURE @ 22 Vdc	@ 30 Vdc	@ 25.5 Vdc	-40°F @ 25.5 Vdc	+150°F @ 25 Vdc
60.00	3.4 -	3.3 -	- (3.1)	3.8 -	3.6 -
61.00	3.3 -	3.3 -	4.1 -	3.8 -	3.5 -
62.00	3.3 -	3.2 -	- (3.1)	3.8 -	3.5 -
63.00	3.3 -	3.2 -	4.1 -	3.7 -	3.3 -
64.00	3.2 -	3.2 -	- (3)	3.8 -	3.3 -
65.00	3.2 -	3.2 -	4.0 -	3.8 -	3.4 -
66.00	3.2 -	3.2 -	- (3)	3.6 -	3.4 -
67.00	3.2 -	3.2 -	4 -	3.6 -	3.4 -
68.00	3.2 -	3.2 -	- (2.9)	3.6 -	3.4 -
69.00	3.2 -	3.2 -	3.9 -	3.6 -	3.4 -
70.00	3.2 -	3.2 -	- (2.9)	3.8 -	3.5 -
71.00	3.3 -	3.2 -	3.9 -	3.8 -	3.5 -
72.00	3.4 -	3.3 -	- (3)	3.9 -	3.6 -
73.00	3.6 -	3.5 -	4.1 -	4 -	3.8 -
74.00	3.4 -	3.4 -	- (3)	3.4 -	3.6 -
75.00	3.4 -	3.3 -	3.8 -	2.6 -	3.6 -
75.95	3.4	3.3 -	3.8 (2.9)	2.0 -	3.5 -

TABLE 5

LOW POWER OUTPUT, RT-246, SET #2

ECOM DATA, (CONTRACTOR DATA) WATTS

FREQUENCY (MHz)	ROOM TEMPERATURE @ 22 Vdc		@ 30 Vdc		@ 25.5 Vdc		-40°F @ 25.5 Vdc	+150°F @ 25 Vdc
30.00	-	(3.3)	-	(2.8)	3	2.9		
32.00	-	(3.4)	-	(3)	3	3.1		
34.00	-	(3.5)	-	(3)	3.2	3		
36.00	-	(3.5)	-	(3)	3.2	3		
38.00	-	(3.2)	-	(2.8)	2.9	2.7		
40.00	-	(3.1)	-	(2.7)	2.8	2.6		
42.00	-	(3)	-	(2.6)	2.8	2.45		
44.00	-	(3)	-	(2.6)	2.6	2.6	NO DATA	NO DATA
46.00	-	(3)	-	(2.6)	2.6	2.5	RECORDED	RECORDED
48.00	-	(2.6)	-	(2.3)	2.4	2.3		
50.00	-	(2.7)	-	(2.3)	2.4	2.2		
52.00	-	(2.5)	-	(2.2)	2.3	2.1		
52.95	-	(2.4)	-	(2.1)	2.2	2.0		
53.00	-	(2.7)	-	(2.3)	3.4	2.1		
54.00	-	(2.7)	-	(2.3)	-	2.3		
55.00	-	-	-	-	3.5	-		
56.00	-	(2.7)	-	(2.3)	-	2.2		
57.00	-	-	-	-	3.5	-		
58.00	-	(2.7)	-	(2.3)	-	2.3		
59.00	-	-	-	-	3.5	-		

TABLE 5, LOW POWER OUTPUT, RT-246, SET #2 (Continued)

ECOM DATA, (CONTRACTOR DATA) WATTS

FREQUENCY	ROOM TEMPERATURE						-40°F	+150°F
(MHz)	@ 22 Vdc		@ 30 Vdc		@ 25.5 Vdc		@ 25.5 Vdc	@ 25 Vdc
60.00	-	(2.7)	-	(2.3)	-	2.2		
61.00	-	-	-	-	3.5	-		
62.00	-	(2.8)	-	(2.3)	-	2.3		
63.00	-	-	-	-	3.5	-		
64.00	-	(2.8)	-	(2.4)	-	2.2		
65.00	-	-	-	-	3.5	-		
66.00	-	(2.7)	-	(2.4)	-	2.3	NO DATA	NO DATA
67.00	-	-	-	-	3.5	-	RECORDED	RECORDED
68.00	-	(2.6)	-	(2.4)	-	2.2		
69.00	-	-	-	-	3.5	-		
70.00	-	(2.5)	-	(2.3)	-	2.1		
71.00	-	-	-	-	3.3	-		
72.00	-	(2.5)	-	(2.2)	-	2.1		
73.00	-	-	-	-	3.2	-		
74.00	-	(2.5)	-	(2.1)	-	-		
75.00	-	-	-	-	3.2	2.1		
75.95	-	(2.5)	-	(2.1)	3	2.1		

TABLE 6

LOW POWER OUTPUT, RT-524, SET #3

ECOM DATA, (CONTRACTOR DATA) WATTS

FREQUENCY (MHz)	ROOM TEMPERATURE @ 22 Vdc		@ 30 Vdc		@ 25.5 Vdc		-40°F @ 25.5 Vdc	+150°F @ 25 Vdc	
30.00	-	(3.7)	-	(3.4)	3.6	(3.4)		-	(3.9)
32.00	-	(3.7)	-	(3.5)	3.6	(3.5)		-	(3.9)
34.00	-	(3.7)	-	(3.4)	3.6	(3.4)		-	(3.8)
36.00	-	(5.7)	-	(5.2)	5	(5.3)		-	(5.9)
38.00	-	(3.8)	-	(3.6)	3.8	(3.6)		-	(4)
40.00	-	(3.5)	-	(3.2)	3.5	(3.2)		-	(3.7)
42.00	-	(3.5)	-	(3.2)	3.8	(3.2)		-	(3.7)
44.00	-	(3.5)	-	(3.2)	3.6	(3.2)	NO DATA	-	(3.7)
46.00	-	(3.2)	-	(3.1)	3.4	(3.1)	RECORDED	-	(3.6)
48.00	-	(3)	-	(2.9)	3.2	(2.9)		-	(3.3)
50.00	-	(2.9)	-	(2.7)	3	(2.6)		-	(3.2)
52.00	-	(2.95)	-	(2.6)	2.8	(2.6)		-	(3.1)
52.95	-	-	-	(2.6)	2.9	(2.7)		-	(3.1)
53.00	-	(3.4)	-	(3.1)	3.2	(3.2)		-	(3.6)
54.00	-	(3.4)	-	(3.1)	-	(3.2)		-	(3.6)
55.00	-	-	-	-	3.3	-		-	-
56.00	-	(3.3)	-	(3)	-	(3.1)		-	(3.5)
57.00	-	-	-	-	3.2	-		-	-
58.00	-	(3.3)	-	(3)	-	(3.1)		-	(3.5)
59.00	-	-	-	-	3.2	-		-	-
60.00	-	(3.2)	-	(2.95)	-	(3)		-	(3.4)
61.00	-	-	-	-	3.2	-		-	-

TABLE 6, LOW OUTPUT POWER, RT-524, SET #3 (CONTINUED)

ECOM DATA, (CONTRACTOR DATA) WATTS

FREQUENCY (MHz)	ROOM TEMPERATURE						-40°F	+150°F	
	@ 22 Vdc		@ 30 Vdc		@ 25.5 Vdc		@ 25.5 Vdc	@25.5 Vdc	
62.00	-	(3.2)	-	(2.9)	-	(2.8)		-	(3.4)
63.00	-	-	-	-	3.1	-		-	-
64.00	-	(3.1)	-	(2.85)	-	(2.9)		-	(3.4)
65.00	-	-	-	-	3	-		-	-
66.00	-	(3)	-	(2.8)	-	(2.8)	NO DATA	-	(3.3)
67.00	-	-	-	-	2.9	-	RECORDED	-	-
68.00	-	(3)	-	(2.8)	-	(2.8)		-	(3.3)
69.00	-	-	-	-	2.9	-		-	-
70.00	-	(3.1)	-	(2.8)	-	(2.6)		-	(3.3)
71.00	-	-	-	-	2.8	-		-	-
72.00	-	(3.2)	-	(2.9)	-	(2.9)		-	(3.3)
73.00	-	-	-	-	2.9			-	-
74.00	-	(3.1)	-	(2.9)	-	(2.9)		-	(3.3)
75.00	-	-	-	-	2.8	-		-	-
75.95	-	(3.1)	-	(2.85)	2.9	(2.9)		-	(3)

TABLE 7

SPURIOUS EMISSIONS TEST, SET #1 RT-524

SPECIFICATION ITEM 3.5.3

f_o = 34.5 MHz		f_o = 46 MHz	
Receive Freq.	dB of Quieting	Receive Freq.	dB of Quieting
34.35	13.5	46	21
34.4	18	46.05	11
34.45	18	46.1	10
34.5	26	46.25	12
34.55	18.5	69	16
34.6	17.5		
34.65	14		
56.5	19.5		

f_o = 57.5 MHz		f_o = 69 MHz	
Receive Freq.	dB of Quieting	Receive Freq.	dB of Quieting
57.4	11	66.5	25.5
57.45	20	68.5	11.5
57.5	25	69	43
57.55	20	69.25	12
57.6	15	72.15	33
57.65	12	73.65	28
60.1	18	74.75	23

TABLE 8

HARMONICS

CONTRACTOR DATA

TRANSMITTER UNDER TEST	30 dB ATTEN.	TRAP	H.P. SPECTRUM ANALYZER

SET #1

F_C = 30 MHz 2nd harmonic down 90 dB from the carrier

3rd harmonic down 85 dB from the carrier

F_C = 55 MHz 2nd harmonic down 80 dB from the carrier

3rd harmonic down 90 dB from the carrier

SET #2

F_C = 30 MHz 2nd harmonic down 90 dB from the carrier

3rd harmonic down 86 dB from the carrier

SET #3

F_C = 30 MHz 2nd harmonic down 90 dB from the carrier

3rd harmonic down 90 dB from the carrier

F_C = 55 MHz 2nd harmonic down 90 dB from the carrier

3rd harmonic down 90 dB from the carrier

TABLE 9

TRANSMITTER INTERMODULATION

ECOM DATA (CONTRACTOR DATA)

SET NUMBER	FREQUENCY	NF 105 READING dB	dB BELOW REF.
#1, RT-524	@ 42 MHz	-53 dBm	23 (20)
	@ 38 MHz	-76 dBm	
#2, RT-246	@ 42 MHz	-53 dBm	25.5 (19)
	@ 38 MHz	-78.5 dBm	
#3, RT-524	@ 42 MHz	-53 dBm	26.5 (20)
	@ 38 MHz	-79.5 dBm	

Unit under test transmitting @ 40 MHz
Interfering unit transmitting @ 42 MHz
3rd Order product @ 38 MHz

See Figures 11a, 11b, and 11c for the results obtained with the spectrum analyzer.

TABLE 10

CURRENT INPUT (AMPS)

ROOM TEMPERATURE, HIGH POWER (NO FAN)

ECOM DATA (CONTRACTOR DATA)

FREQUENCY MHz	SET #1 RT-524 @ 25 Vdc		SET #2 RT-246 @ 25 Vdc		SET #3 RT-524 @ 25 Vdc	
30	6.9	(7.2)	6.7	(7)	7.4	(7.5)
32	6.5	(6.8)	5.9	(7)	6.7	(6.5)
34	6	(6)	5.7	(6.4)	7.4	(6.5)
36	6	(6)	6.3	(6.8)	7.7	(7.6)
38	6.7	(6.6)	6.3	(6.8)	7.5	(7.5)
40	5.9	(6.1)	6.3	(6.5)	7.4	(7)
42	5.8	(5.8)	6.3	(6.1)	8.4	(6.8)
44	6.4	(6.4)	6.7	(6)	8.1	(7.2)
46	7.9	(7.9)	6.5	(6.2)	8	(8.2)
48	7.9	(7)	6.1	(8)	8	(8.2)
50	7.6	(6.8)	5.8	(7.7)	6.5	(6.3)
52	6.3	(6.2)	5.8	(6.4)	6.8	(6.8)
52.95	6.4	(6.3)	6.05	(6.2)	7.3	(7.3)
53	7.2	(7)	5.65	(5.9)	7.3	(7.3)
54	-	(7.5)	-	(6)	-	(7)
55	6.6	-	5.7	-	6.5	-
56	-	(7.2)	-	(6)	-	(6.2)
57	6.2	-	5.6	-	5.7	-
58	-	(6.6)	-	(6)	-	(5.6)
59	5.5	-	5.75	-	5.2	-

TABLE 10 (Continued)

CURRENT INPUT (AMPS)

ROOM TEMPERATURE, HIGH POWER (NO FAN)

ECOM DATA (CONTRACTOR DATA)

FREQUENCY MHz	SET #1 RT-524		SET #2 RT-246		SET #3 RT-524	
	@ 25 Vdc		@ 25 Vdc		@ 25 Vdc	
60	-	(5.9)	-	(6)	-	(5.5)
61	5.2	-	5.8	-	5.1	-
62	-	(6)	-	(6)	-	(5.26)
63	5.2	-	5.85	-	5.1	-
64	-	(5.9	-	(6)	-	(5.6)
65	5.3	-	5.8	-	5.5	-
66	-	(6)	-	(5.9)	-	(6)
67	5.5	-	5.8	-	5.6	-
68	-	(6.4)	-	(5.8)	-	(6.3)
69	6	-	5.6	-	5.9	-
70	-	(6.4)	-	(5.5)	-	(6.2)
71	6.2	-	5.5	-	6.1	-
72	-	(6.5)	-	(5.4)	-	(6)
73	6.4	-	5.5	-	6.2	-
74	-	(6.5)	-	(5.5)	-	(5.8)
75	6.2	-	5.8	-	5.8	-
75.95	6	(6.4)	5.5	(5.8)	5.8	(5.7)

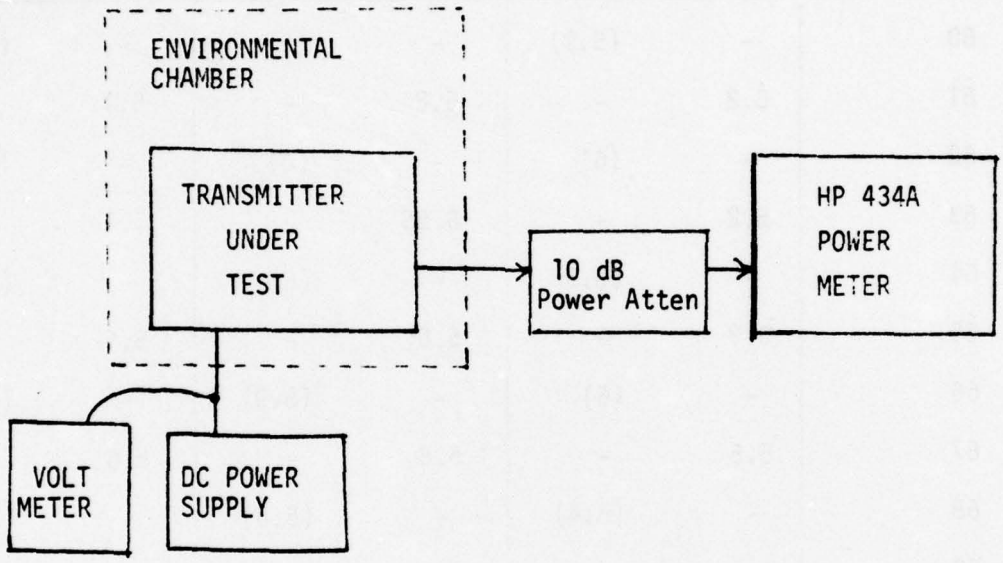

FIGURE 1

TEST SET UP FOR POWER OUTPUT

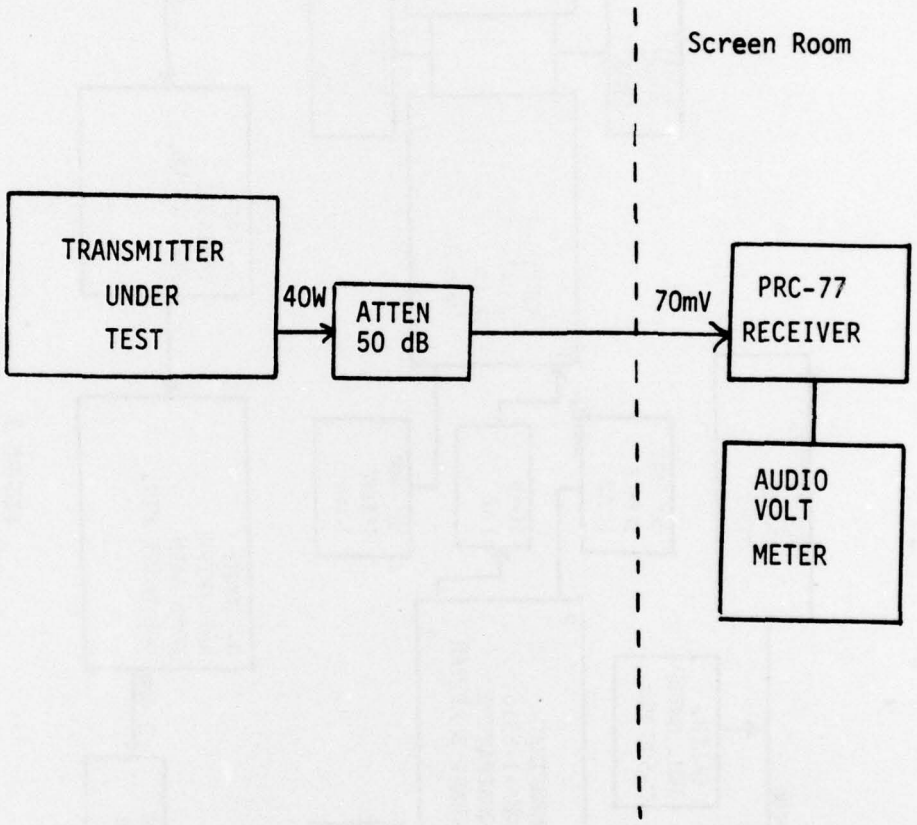

FIGURE 2

TEST SET UP FOR SPURIOUS RESPONSE SPECIFICATION ITEM PARAGRAPH 3.5.3

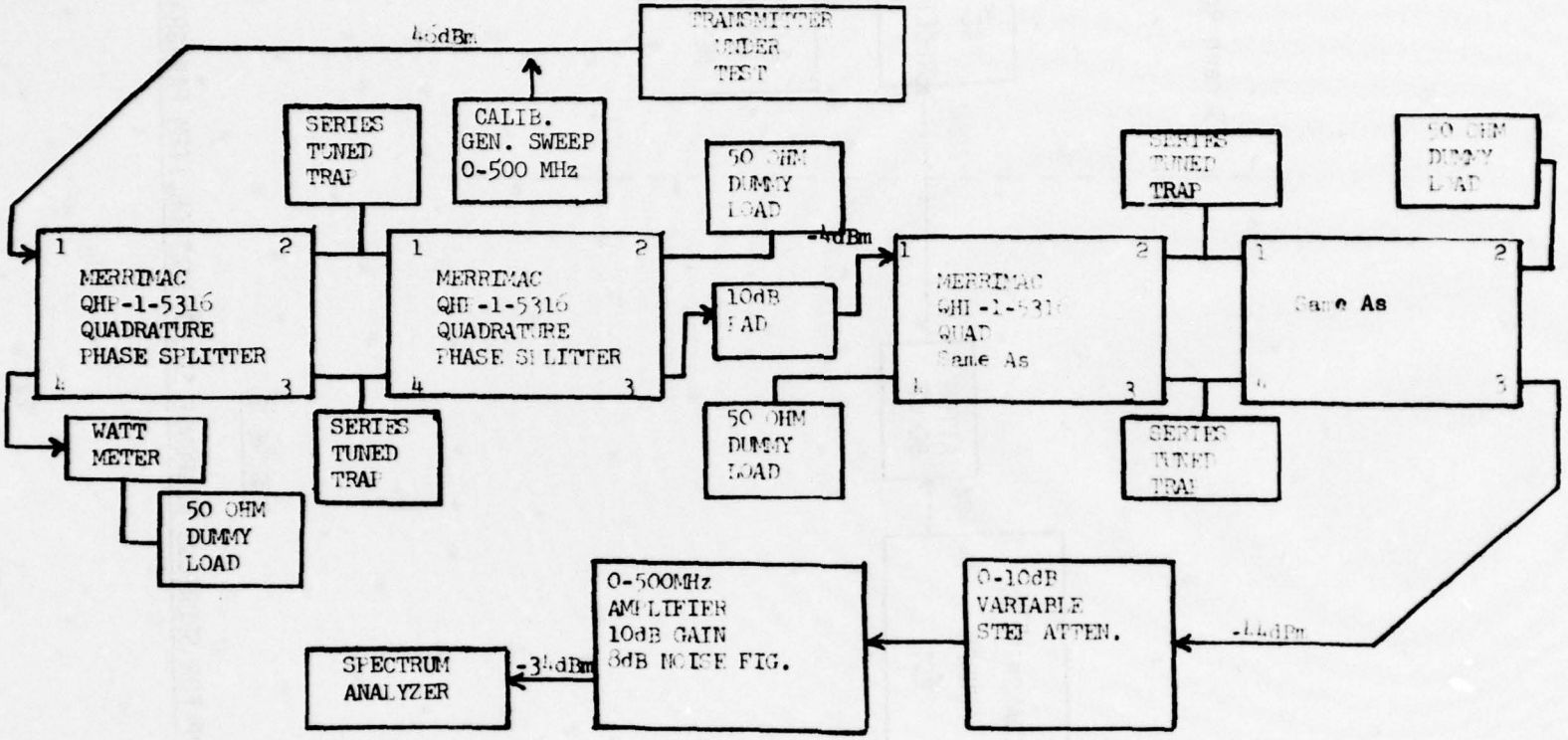

FIGURE 3
TEST SET-UP FOR NOISE FLOOR
MEASUREMENTS AND HARMONIC EMISSIONS

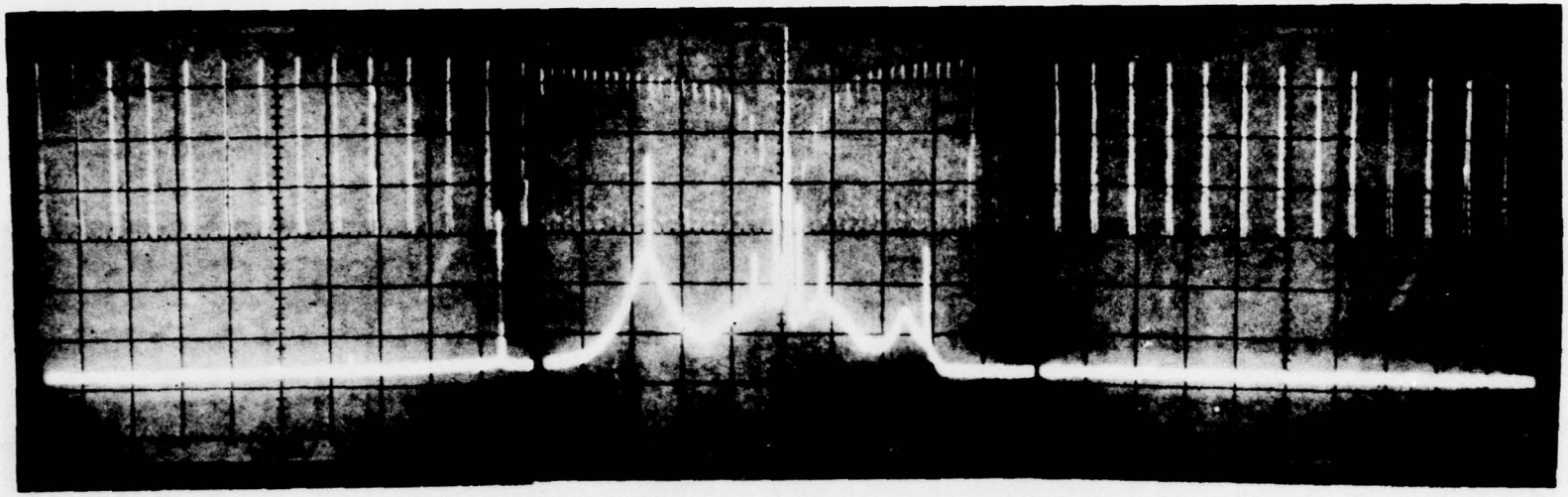

FIGURE 4a. RT-524/VRC TRANSMITTER NOISE SPECTRA LOW BAND

(a) Set #1; F_o = 52 MHz; P_o = 40 W (46dBm);

CALIB MARKS = -40dBm; SWEEP = (22-82) MHz (2 MHz/cm);

VERT = 10 dB/cm; BANDWIDTH = 30 kHz.

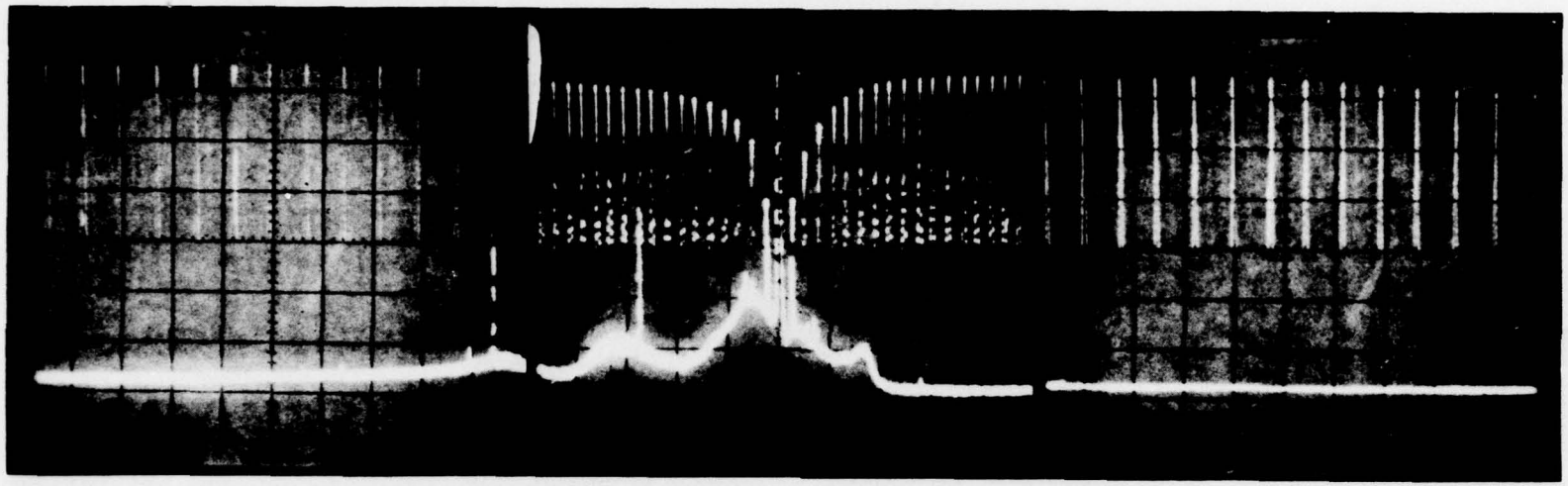

FIGURE 4b. RT-246/VRC TRANSMITTER NOISE SPECTRA LOW BAND

(b) SET #2; F_o = 52 MHz; P_o = 40 W (46dBm);

CALIB. MARKS = -40 dBm; SWEEP = 22-82 MHz (2 MHz/cm);

VERT. = 10 dB/cm; BANDWIDTH - 30 kHz.

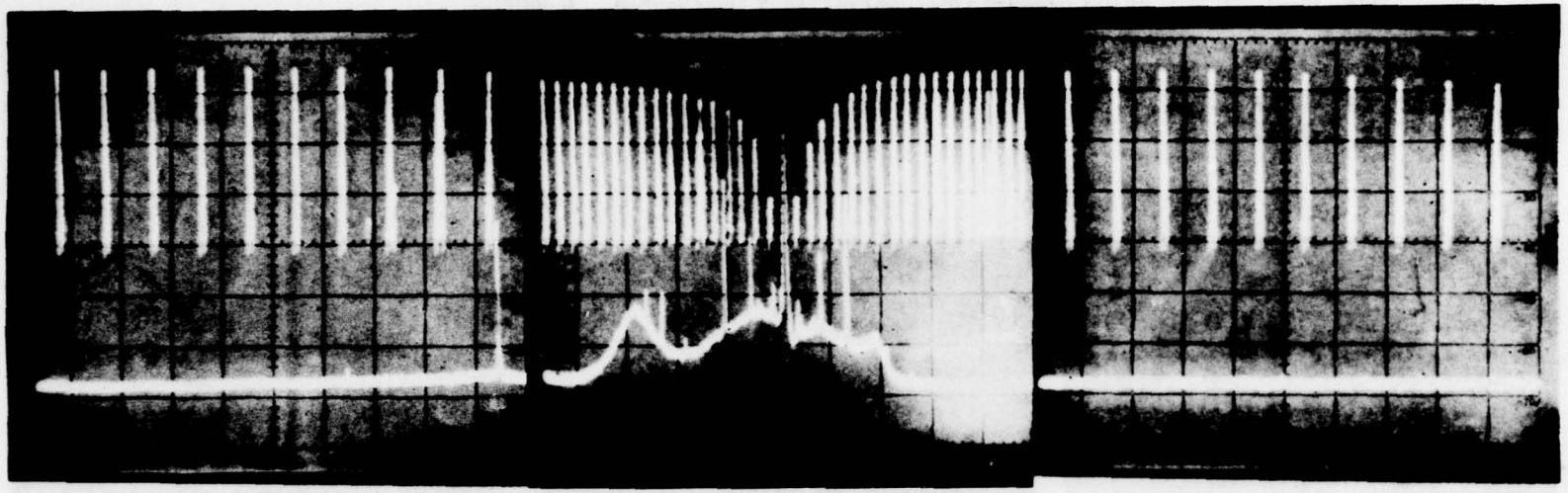

FIGURE 4c. RT-524/VRC TRANSMITTER NOISE SPECTRA LOW BAND

(c) SET #3; F_o = 52 MHz; P_o = 40 W (46 dBm);

CALIB. MARKS = -40 dBm; SWEEP = 22-82 MHz (2 MHz/cm);

VERT. = 10 dB/cm; BANDWIDTH = 30 kHz.

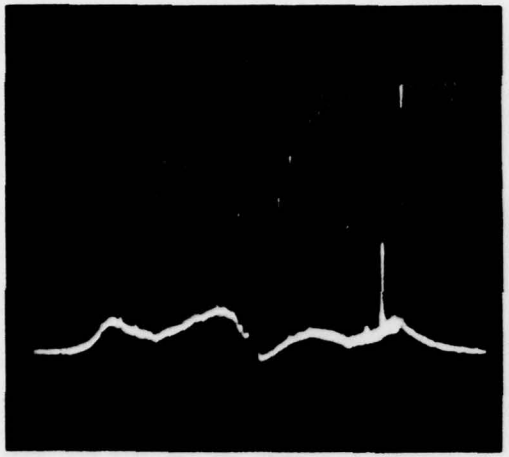

FIGURE 5a.
SET #1 RT-524/VRC

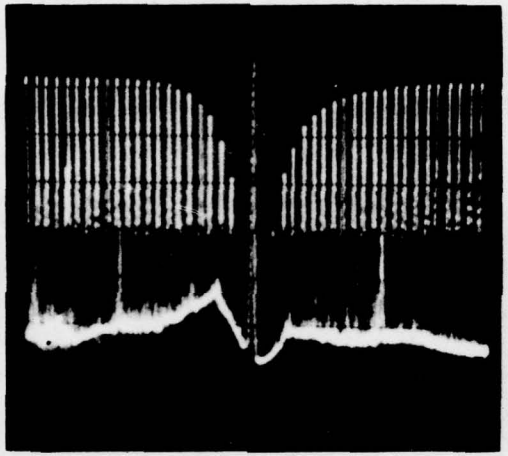

FIGURE 5b.
SET #2 RT-246/VRC

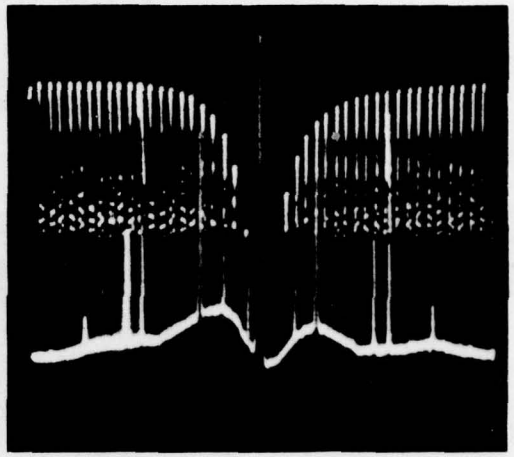

FIGURE 5c.
SET #3 RT-524/VRC

FIGURE 5. RT-524/VRC & RT-246/VRC TRANSMITTER NOISE SPECTRA HIGH BAND

F_o = 60 MHz; P_o = 40 W (46 dBm); CALIB MARKS = -40 dBm;

SWEEP = 50-70 MHz (2 MHz/cm); BANDWIDTH = 30 kHz.

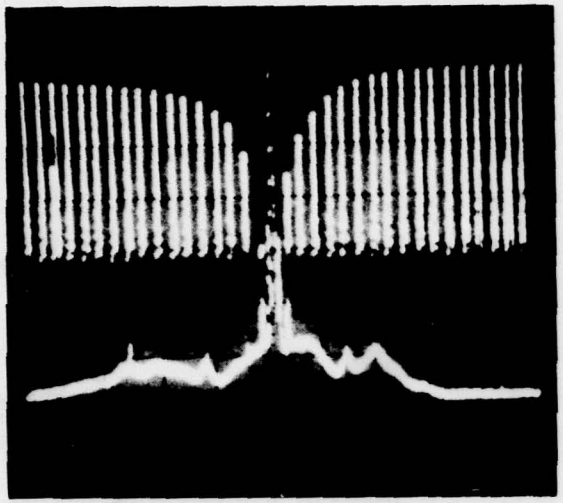

FIGURE 6a.
RT-524/VRC TUBE TYPE SET

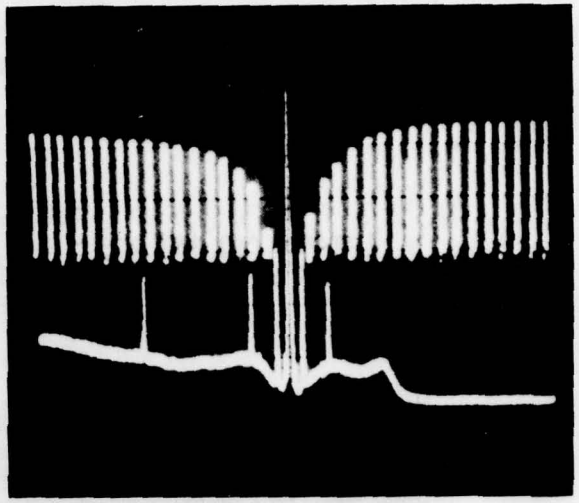

FIGURE 6b.
BROADBAND SOLID STATE MODEL
FROM PREVIOUS CONTRACT

FIGURE 6. RT-524/VRC TRANSMITTER NOISE SPECTRA

F_o = 52 MHz; P_o = 40 W (46 dBm);

CALIB. MARKS = - 40 dBm; SWEEP = 42-62 MHz (2 MHz/cm);

VERT. = 10 dB/cm; BANDWIDTH = 30 kHz.

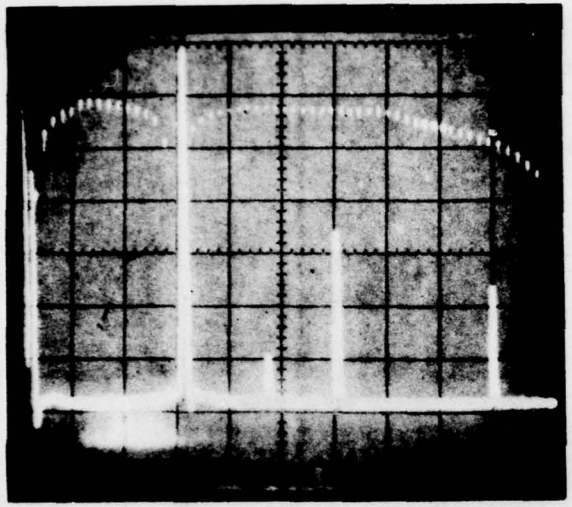

FIGURE 7a
LOW BAND: CALIB. MARKS = -40 dBm
SWEEP - 0 - 100 MHz (10 MHz/cm)
F_o = 30 MHz

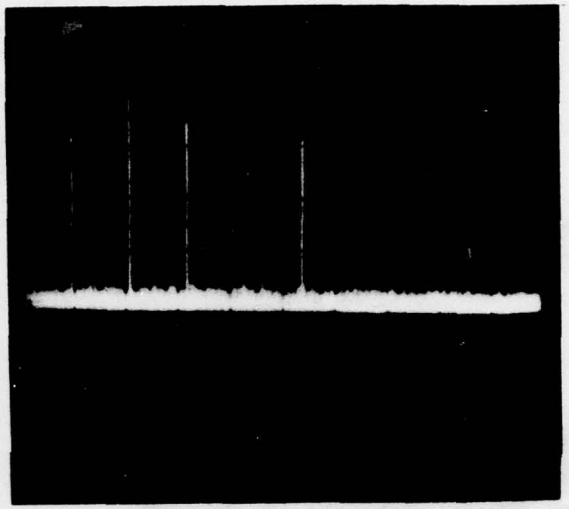

FIGURE 7b
HIGH BAND: TOP SCALE = +13 dBm
SWEEP = 0 - 500 MHz (50 MHz/cm)
F_o = 55 MHz

FIGURE 7. RT-524/VRC HARMONIC EMISSION OF PRESENT TUBE MODEL

P_o = 40W (46 dBm); VERT. = 10 dB/cm);

BANDWIDTH = 30 kHz.

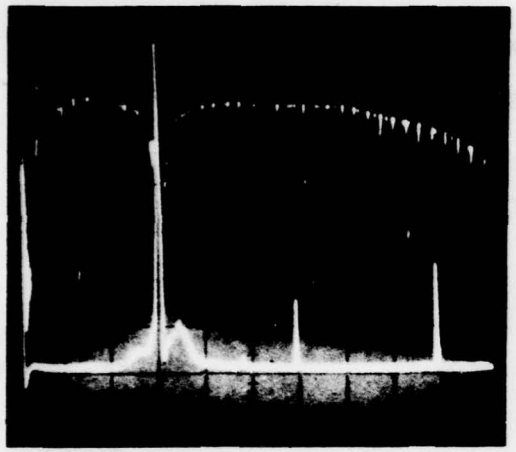

FIGURE 8a.
RT-524/VRC SET #1

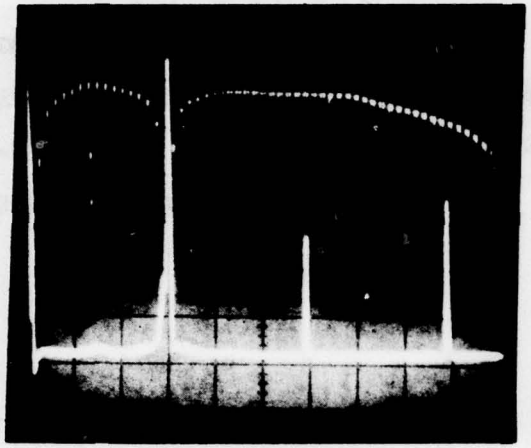

FIGURE 8b.
RT-246/VRC SET #2

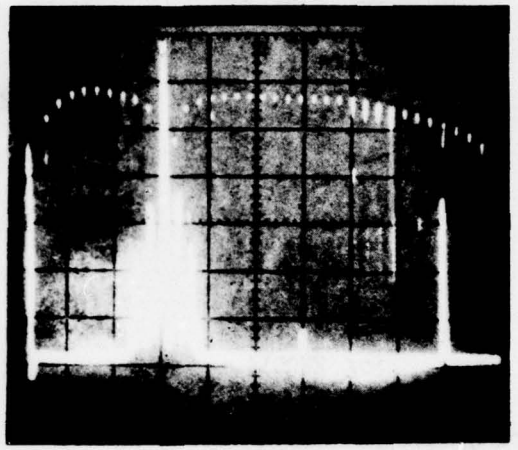

FIGURE 8c.
RT-524/VRC SET #3

FIGURE 8. HARMONIC EMISSION LOW BAND

F_o = 30 MHz; P_o = 40W (46 dBm); CALIB MARKS = 40 dBm

SWEEP = 0-100 MHz (10 MHz/cm); VERT. = 10 dB/cm

BANDWIDTH = 30 kHz.

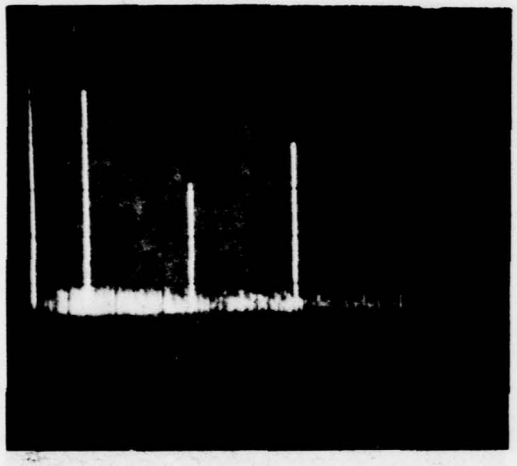

FIGURE 9a.
RT-524/VRC SET #1

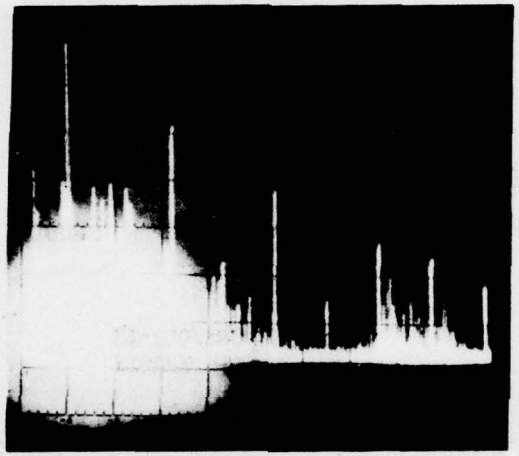

FIGURE 9b.
RT-246/VRC SET #2

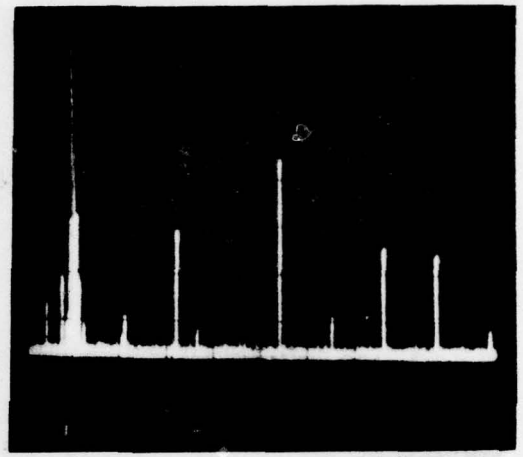

FIGURE 9c.
RT-524/VRC SET #3

FIGURE 9. HARMONIC EMISSION HIGH BAND

F_o = 55 MHz; P_o = 40W (46 dBm); TOP LINE = -15 dBm;

SWEEP = 0-500 MHz (50 MHz/cm); VERT. - 10 dB/cm

BANDWIDTH - 30 kHz.

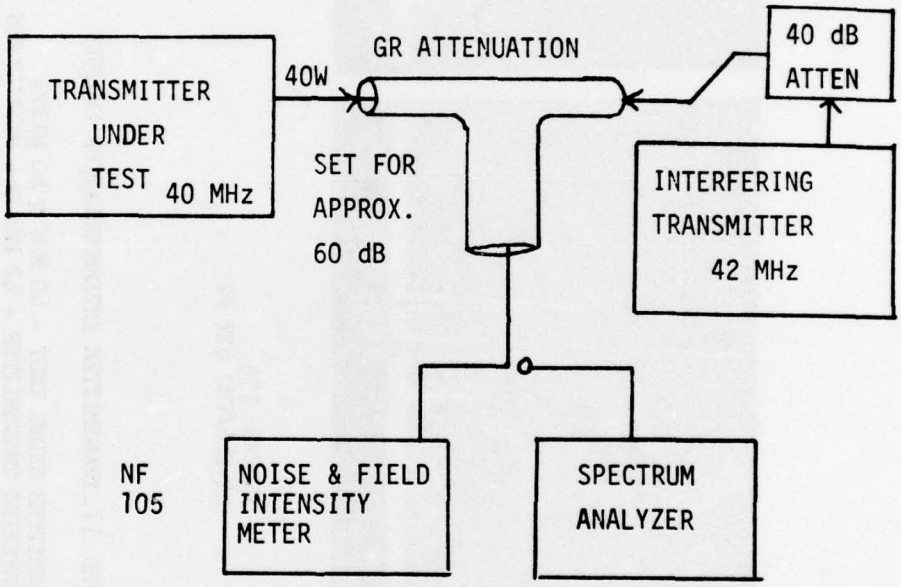

FIGURE 10

TRANSMITTER INTERMODULATION SPECIFICATION ITEM PARAGRAPH 3.5.6

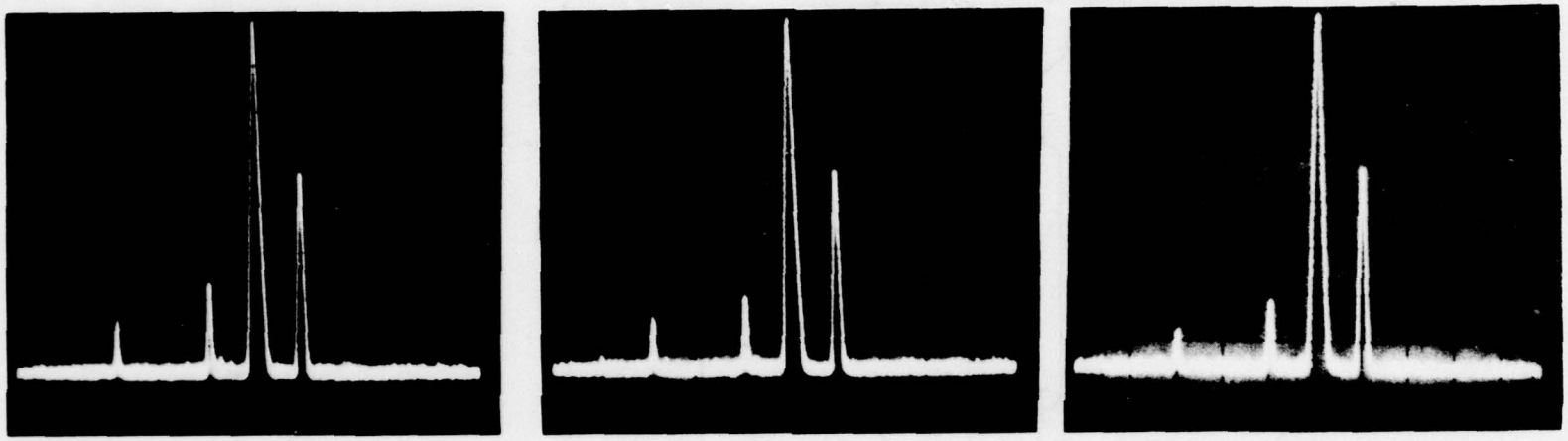

FIGURE 11a.
RT-524/VRC SET #1

FIGURE 11b.
RT-246/VRC SET #2

FIGURE 11c.
RT-524/VRC SET #3

FIGURE 11. TRANSMITTER INTERMODULATION PRODUCT

TRANSMITTER UNDER TEST - 40 MHz @ 40 WATTS
INTERFERING TRANSMITTER - 42 MHz @ 4 MILLIWATTS
SWEEP - 30-50 MHz (2 MHz/cm)
VERT. - 10 dB/cm
BANDWIDTH - 30 kHz

APPENDIX A

TEST EQUIPMENT

EQUIPMENT TYPE	USED IN TEST	CALIBRATION DATE
LAMBDA LE 103 Regulated Power Supply SN C22375	All tests	Not Required
Hewlett Packard 3476B Digital Volt Meter SN 1605A00498	All tests	June 1976
20 dB Attenuator	Spurious Response Transmitter Intermodulation	User Calibrated
10 dB Attenuator	Power Output Spurious Response	User Calibrated
Hewlett Packard 355D Attenuator SN 219-00133	Spurious Response Noise Floor and Harmonic Output	User Calibrated
Hewlett Packard 355A Attenuator SN none	Noise Floor and Harmonic Output	June 1976
Hewlett Packard 434A Power Meter SN 001-00414	Power Output Tests	January 1976
AN/PRC-77 FM Transceiver SN 7217	Spurious Emissions	Not Required

APPENDIX A, TEST EQUIPMENT (Continued)

EQUIPMENT TYPE	USED IN TEST	CALIBRATION DATE
Hewlett Packard 403B AC Voltmeter SN 523-04105	Spurious Emissions	February 1976
Merrimac (4 each) QHP-1-5316 Quatrator Phase Splitter	Noise Floor Harmonics Intermodulation	User Calibrated
ANAREN AM-101 RF Amplifier	Noise Floor	User Calibrated
Hewlett Packard 8553L Spectrum Analyzer SN 902-00507	Noise Floor Harmonics Intermodulation	August 1976
Hewlett Packard 8544L Spectrum Analyzer SN 991-02933	Noise Floor Harmonics	August 1976
Empire NF-105 Noise & Field Intensity Meter SN 736	Intermodulation	October 1975
General Radio 874-GA Variable Tee Attenuator	Intermodulation	User Calibrated
DC Polyranger Model C2 Amp Meter Sensitive Research Instrument Corp	DC input current	January 1976